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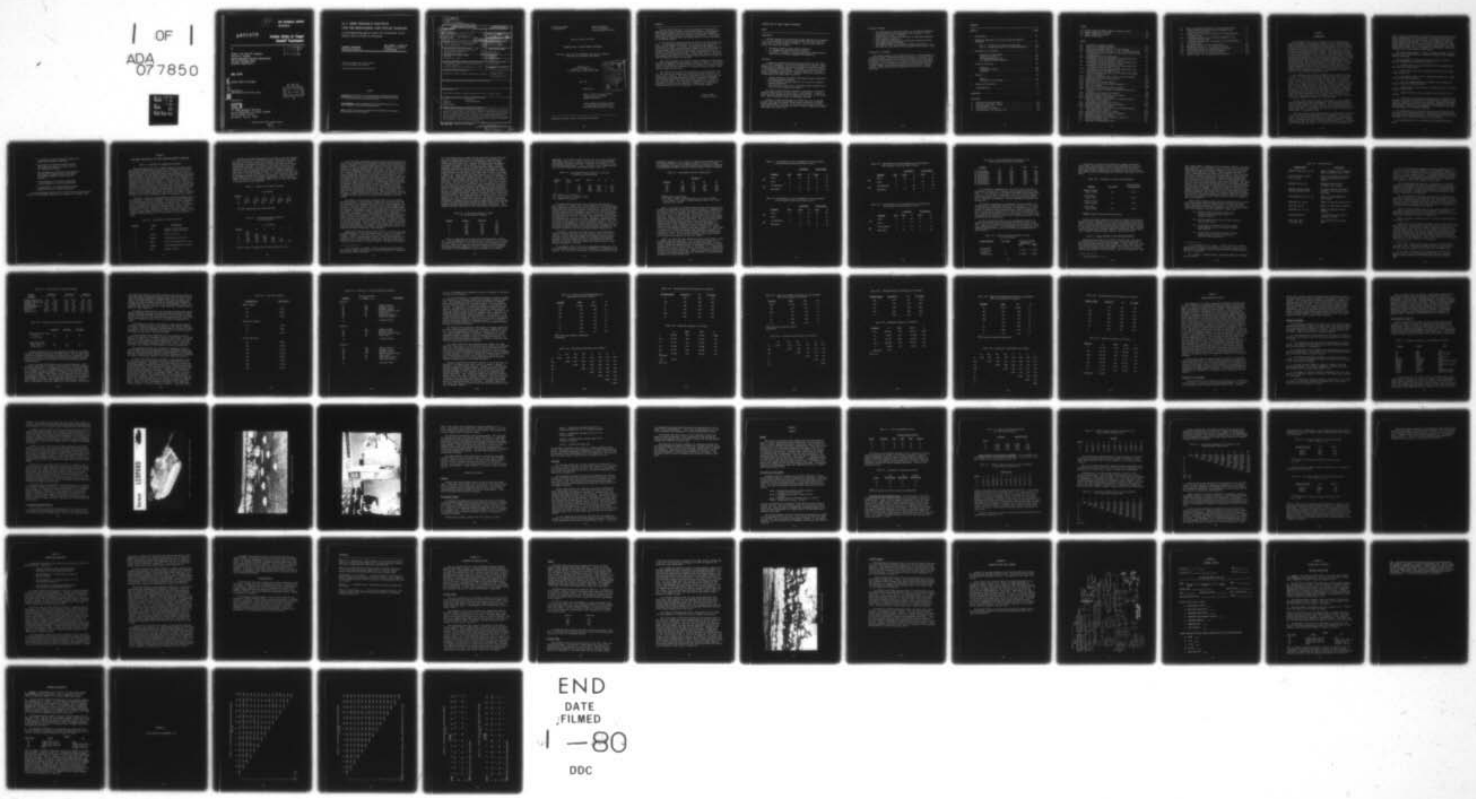

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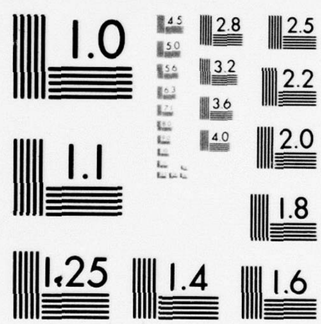

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Further Study of Target Handoff Techniques

LEVEL II

by

William H. Ton, Peter W. Hemingway,
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A series of studies were aimed at improving the performance of aviators engaged in target handoff. This report focuses on selection and training as avenues to improved performance and on the role of long range target recognition and identification. Results indicate that simple unguided practice under simulated conditions may be the most effective means of improving handoff performance. The report is written for behavioral scientists, although results are of interest to military personnel.

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FURTHER STUDY OF TARGET HANDOFF TECHNIQUES

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May 1979

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FOREWORD

The Fort Hood Field Unit of the Army Research Institute for the Behavioral and Social Sciences (ARI) provides support to Headquarters, TCATA (TRADOC Combined Arms Test Activity; formerly called MASSTER--Modern Army Selected Systems Test Evaluation and Review). This support is provided by assessing human performance aspects in field evaluations of man/weapons systems.

A war using modern weapons systems is likely to be both intense and short. US man/weapons systems must be effective enough, immediately, to offset greater numbers of an enemy. Cost-effective procurement of improved or new combat systems requires testing that includes evaluation of the systems in operational settings similar to those in which the systems are intended to be used, with troops representative of those who would be using the systems in combat. The doctrine, tactics, and training packages associated with the systems being evaluated must themselves also be tested and refined as necessary.

This report presents the results of studies designed to investigate problems in handing off targets between elements of Army air. The studies specifically addressed the effectiveness of recognition training and simulation in improving the performance of personnel who must perform target handoff as part of their job.

ARI research in this area is conducted as an in-house effort, and as joint efforts with organizations possessing unique capabilities for human factors research. The research described in this report was done by personnel of the Human Resources Research Organization (HumRRO), under contract DAHC19-75-C-0025, monitored by personnel from the ARI Fort Hood Field Unit. This research is responsive to the special requirements of TCATA and the objectives of RDTE Project 2Q763743A775, "Human Performance in Field Assessment," FY 1978 Work Program.

JOSEPH ZEIDNER
Technical Director

FURTHER STUDY OF TARGET HANDOFF TECHNIQUES

BRIEF

Requirement:

The work carried out in this study is that referred to in paragraph 2.2.1 of the Statement of Work (revised) dated 16 May 1977 under the title "Study of Target Handoff Techniques." The following objectives guided the course of the study:

- To develop improved target handoff procedures.
- To recommend new target handoff procedures.
- To produce a statement of Required Operational Characteristics (ROC) for new or revised equipment/instrumentation.

Procedure:

A relatively sophisticated technology was evolved for the production of static imagery to be used in the simulation of handoff. This imagery was used together with improved hardware to study the behavior of individuals performing handoff. In addition, an effort was focused on the development of an 80-minute slide/tape program in long range target recognition/identification. Research using these resources was concentrated around three major activities:

- Content analyses of the verbal interchange between individuals performing simulated handoffs.
- The evaluation of unguided practice as an avenue to improved handoff performance.
- The evaluation of the role of long range target identification skills in target handoff performance.

The first activity involved analyses of transcripts of simulated handoff obtained during the second year of the research. A number of hypotheses were proposed based on observation and review of the literature. These hypotheses guided the subsequent analyses.

Secondly, a study was designed to evaluate the role of unguided practice and long range target identification training on simulated handoff performance. Subjects for the study were 44 pairs of experienced aviators and scouts from the Sixth US Cavalry Brigade (Air Combat) (6th ACCB), Fort Hood, Texas.

Principal Findings:

- The technology for producing imagery for the handoff simulation and the identification training has great potential for the development of low-cost training.
- General handoff practice was effective in improving performance under simulated conditions.
- The recognition/identification training was effective but did not enhance handoff performance.
- Each handoff situation was seen as probably being unique. If this were the case, then each would require its own set of rules.

Utilization of Findings:

The primary product of this research activity is the development of a systematic means of improving handoff performance. Prototypes of the required training hardware and the supporting software were developed and details for the construction of future training has been furnished. In addition, four prototypes were delivered of an extremely effective training package in long range recognition/identification of armored vehicles. This training fills an existing critical void in the Army curriculum.

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Chapter 1

INTRODUCTION

Target handoff occurs when an individual or unit requests that another individual or unit engage a target. There are many reasons in combat for handing off targets and the handoff itself can occur between a wide variety of elements ranging from individuals to units. The dif-fficulty of achieving a successful handoff varies with the location of the elements participating in the activity. As an example, it is relatively easy for ground observers to handoff (designate) ground targets to other ground elements. In this instance, both will likely be viewing the target and surrounding terrain from a similar perspective. The task becomes more difficult when a scout helicopter designates targets for an Attack Helicopter (AH) as the aerial perspective from which both are viewing the target will probably differ to an unknown extent. However, air-to-ground and ground-to-air handoffs are the most difficult. The common denominator in all of these situations is the difference in viewing perspective between the two individuals attempting a handoff. Because of this fundamental similarity, an improvement in handoff techniques for one situation should apply to all.

The current research focuses on handoff between elements of Army Aviation. In combat the most likely handoff will be from an aeroscout to an AH. The most likely target will be enemy armor or an enemy air defense system. Tactics dictate that the scout, after locating the target, will direct the AH to the target. Typically, the scout will be closer to the target than the AH, and there will be an angular difference in their viewing positions. The range to the target from the AH will be dictated by the type of target being engaged and the weapons being used. This range may exceed 3500 meters. Thus, the differences in viewing perspective which cause difficulty in designation of the proper target are compounded by the extreme ranges likely to be encountered. High power optics are available but their limited field of view renders them nearly useless as an aid in search.

The use of maps by both aircraft cooperating in a target handoff cannot be expected to improve performance. The usefulness of maps in this situation depends on a high degree of skill in map-terrain association on the part of both parties, and the 1:250,000 scale maps lack much useful detail. In addition, the accuracy of maps in many potential combat zones is an unknown factor.

The Asian experience was characterized by unquestioned US air superiority and the lack of significant local air defense by enemy combat units. The conflict was also basically an infantry or guerilla action with few defined positions and very little armor involvement. Handoff procedures as they now exist are heavily influenced by the recent experience in Southeast Asia (SEA). It is unlikely that the SEA experience will be repeated, and therefore the techniques that were developed there will be inappropriate for future combat. Interviews with aviators revealed that each unit has developed its own techniques and there is little commonality among these. In addition, a number of these techniques require direct visual contact between scout and AH; i.e., hand signals, flash cards, etc. Obviously there are many combat situations where visual contact will not be possible (or desirable). Hence, these techniques are of only marginal effectiveness.

The obvious shortcomings of current techniques indicated a severe need for a more effective means of handing off targets while engaging a sophisticated enemy.

For the purposes of further defining the problem, a number of limiting assumptions were proposed as follows:

1. Handoff will occur in an environment with topography and climate typical of Central Europe.

2. Handoff will occur in a mid-intensity conflict with conventional weapons only.

3. The conflict will be with a sophisticated enemy with an Electronic Warfare (EW) capability.

4. Local air superiority will be doubtful and the enemy will possess strong air defense capability.

5. Handoff will be from a ground or airborne observer to an AH or gunship, or vice versa.

6. Handoff to USAF or Navy air support units will not be considered.

7. Direction to the target and designation of the target will be by verbal radio contact--which must be used sparingly. This worst case approach to handoff is dictated by the realistic assumption that combat conditions will degrade or render inoperable any sophisticated systems. This assumption also focuses the emphasis of the research on the most variable element in the handoff--the human.

The primary goal of the research described in this report was to develop a further understanding of the target handoff task and to model the behaviors and processes involved. Once the task is understood, then hypotheses can be proposed for improving its performance.

To achieve the goals of the research, the following steps were taken:

- A re-analysis of data obtained on handoffs performed under simulated conditions.

- The design of an improved handoff simulator which would also serve as a system test bed for evaluating procedures.

- The development of stimuli for the simulation which would be highly realistic and reflect the limiting assumptions which guide the research.

- An investigation of the role of long range target recognition on handoff performance.

- An evaluation of the effectiveness of simple unguided practice on handoff performance.

The following pages describe each of these steps in detail and how each led to an increased insight into the nature of the handoff task.

Chapter 2

ADDITIONAL EVALUATION OF THE FIRST GENERATION HANDOFF SIMULATION

Part I: Re-analysis of Handoff and Test Data

During the second year of the handoff research, the focus of the effort was on problem definition, with the primary goal of describing the behaviors involved in the handoff task. To achieve this end, a handoff simulator was devised which would allow economical collection of behavioral data. In this simple simulation, handoff problems were generated by presenting visual imagery separately to a pair of players by rear projection of 35mm transparencies. One player (the "observer") was supplied the description and location of a target and his task was to communicate this information verbally to a "pilot" player. The pilot's task was to locate the target. The scenario used further specified that although both players were viewing the same area, their positions relative to each other were unknown. Subjects were 116 personnel from the Sixth US Cavalry Brigade (Air Combat) (6th ACCB), Fort Hood, Texas. However, in the analysis reported in this chapter the number of subjects involved will be less, reflecting a number of incomplete data records.

Six pairs of 35mm color transparencies provided the imagery used in the simulation. Each pair consisted of two views of terrain; however, the viewing perspective was different. The six pairs were categorized a priori on the basis of type of handoff problem depicted. Two basic types of problems were identified--area or target. Table 2-1 describes the six problems used. Handoff of problems in the "area" category (Problems 1, 4, and 6) required the location and description of a particular terrain feature; no military target is visible. Members of the "target" category (Problems 2, 3, and 5) feature a visible military target.

Table 2-1. Description of Handoff Problems

Problem	Type	Description
1	Area	Target is tree stand in an overall view of farm land.
2	Target	Convoy off road.
3	Target	Field piece in tree line.
4	Area	House at intersection of road.
5	Target	Truck-mounted shelter in woods.
6	Area	Distant hilltop.

Performance in handoff was gauged on the basis of the time required for a pair of subjects to handoff the targets. The handoff was judged completed when the pilot player had correctly identified the target. The exchange of information between the players continued until correct identification was made. Two composite time scores (in seconds) were computed for each pair of subjects, an Area Score (AS) and a Target Score (TS). Each of these two scores were the unweighted sums of the time required to handoff three problems: AS = Σ time for Problems 1, 4, and 6; TS = Σ time for Problems 2, 3, and 5. These two scores were used as performance criteria for a variety of analyses. Table 2-2 gives the means and SDs for the six problems. Examination of the correlations (Table 2-3) between the six problems seems to give at least some support to the existence of two categories.

Table 2-2. Times for the Handoff Problems

n = 48 Pairs*

Problem	1	2	3	4	5	6
$\bar{x}$	151.87	34.93	63.88	59.58	79.25	66.36
σ	71.54	12.28	65.25	44.51	110.47	69.96
n*	101	102	105	104	105	103

*n = all individuals with valid time data.

Table 2-3. Correlations Between Times for the Six Problems

n = 48 Pairs*

Problem	1	2	3	4	5	6
1	1.000					
2	.265	1.000				
3	.172	.261	1.000			
4	.546	.240	.409	1.000		
5	.278	.130	.426	.199	1.000	
6	.070	.025	.293	.288	.153	1.000

*n = all pairs of subjects with valid time data for both.

One of the major activities during the second contract year was an effort aimed at looking for relationships between various aptitudes and success in handoff. In these analyses the criteria for successful performance were the two composite time measures, AS and TS. The predictors were a perceptual Spatial Factor (SF) score, a Verbal Fluency Factor (VFF) score, experience in handoff, and military job (aviator or other). For a complete description of these variables and the process by which they were computed, the reader is referred to Ton and Kubala.[1] The notion guiding this effort was that spatial factors would influence the performance of pilot players who must perform visual search, while verbal fluency would be involved in the performance of observers who must describe the target and its location. A discriminant function analysis was performed which related these predictors to membership in four categories: effective/ineffective on area targets (AS), and effective/ineffective on military targets (TS). The effective/ineffective dichotomy was determined by splitting the sample of players at the median of the distributions for AS and TS. Thus, each subject would be assigned to either the effective or ineffective categories for each type of handoff problem, based on the time his team required to perform handoff.

The results of this analysis (described fully in Ton and Kubala) were discouraging. It was initially thought that this poor result may have been due to the composite time scores used to form categories; the AS and TS scores were formed on the basis of an a priori judgment and, therefore, could not take into account the actual relationships between the problems. Consequently, early in the third year of the contract, it was decided to review this research, beginning with a reappraisal of the criteria of performance. As a starting point in this reappraisal, a Factor Analysis was performed on the matrix of correlations between the times to solve the six problems. This analysis was intended to empirically determine the general categories of stimuli. A principal factor solution was chosen and the resulting factors were orthogonally rotated to a Varimax criterion. Table 2-4 shows the final rotated factor matrix obtained by this method. All analyses in this report were carried out at ARI-Alexandria utilizing the Univac 1100 multiprocessor system. Programs from the SPSS package were used throughout.

Examination of the two factors shown in Table 2-4 reveals that each is largely defined by a single handoff problem. Factor I is defined by Problem 3 (loading = .943), while Factor II is defined by Problem 1 (loading = .943). Referring back to Table 2-1 for a description of the stimulus pairs for these problems reveals that Problem 1 requires the description and location of a terrain feature. The feature is embedded

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[1] W. H. Ton and A. L. Kubala. *Study of Target Handoff Techniques*, ARI Technical Report, Human Resources Research Organization, Alexandria, Virginia, May 1978 (in process).

in a very complex area of terrain and the long times required for handoff of this problem (Table 2-2) are indicative of great difficulty. Problem 3 is described in Table 2-1 as featuring a military target (field piece) in a tree line. However, the actual projected image of the target in Problem 3 is very unclear to either viewer. With the exception of Problem 4, none of the remaining four problems exhibit sufficient common factor variance (h^2) to allow the emergence of additional factors. For the sake of description, the two sorts of handoff problems defined by this analysis were named Type 1 (Factor I) and Type 2 (Factor II). Factor scores were then computed for each subject in the handoff study. These factor scores served as criteria in a reinvestigation of the determiners of handoff success. For Factor I the range of scores was -.834 to 3.598, with a median and SD of -.404 and .979, respectively. For Factor II the range was -1.515 to 2.103, with a median of -.182 and an SD of .947. The factor score distributions for the two sorts of roles were then divided at the median to form four categories--successful and unsuccessful observers and successful and unsuccessful pilots. A discriminant function analysis (SPSS *Subprogram Discriminant*) was used to classify the subjects into these four mutually exclusive and exhaustive handoff performance categories according to their scores on a set of predictors. These predictors were the same as used in the earlier analysis; i.e., VFF, SF, experience and job. The primary aim of the analysis was to see if these four predictors were useful in predicting performance in handing off the two types of empirically defined problems. A direct solution discriminant analysis was used in which all of the independent variables were entered into the analysis concurrently. The analyses were done separately for each team position (observer or pilot).

Table 2-4. Rotated Factor Matrix of Times for the Six Handoff Problems

Problem	Factor I	Factor II	h^2
1	.053	.943	.893
2	.210	.272	.118
3	.972	.135	.963
4	.346	.556	.429
5	.386	.223	.203
6	.308	.085	.102

Table 2-5 summarizes the initial output from *Subprogram Discriminant*. This program provides two indices of the importance of the obtained discriminant functions. The first of these is the canonical correlation (R_c), which is an index of association between each discriminant function and category membership. R_c^2 is an estimate of the proportion of variance in the discriminant function accounted for by category membership. R_c is shown in Table 2-5 for each of the four categories. The largest value of R_c (.438) in the table is that associated with pilot players and Type 2 problems. This value of .438 with n = 48 is statistically significant ($p < .01$). However, an R_c of this magnitude has only limited practical significance as R_c^2 is only .194.

Table 2-5. Discriminant Function Analysis of Time Data by Position and Problem Type

Problem Type*	Position**	R_c***	Wilks' Λ	x^2	*df*	*p*
1	O	.243	.941	2.137	4	.711
1	P	.138	.981	.690	4	.953
2	O	.303	.908	3.379	4	.497
2	P	.438	.808	7.672	4	.104

*1 = Factor I; 2 = Factor II
**P = Pilot player; O = Observer player
*** = Canonical correlation

The second measure provided by the *Subprogram Discriminant* is Wilks' Lambda (Λ). Lambda is an inverse measure of the discriminating power remaining *after* a function has been extracted. The greater Lambda becomes the less information remains. Lambda may be assessed for statistical significance by computing a chi square (x^2) test and entering the obtained value into appropriate tables. Of the four discriminant functions shown in Table 2-5, only the fourth approaches accepted levels of significance ($x^2 = 7.672$, $p = .104$). The small x^2 associated with the remaining three functions indicates considerable remaining information which is unaccounted for by the discriminant function. Thus, the overall picture presented by the data contained in Table 2-5 is one of a low degree of discrimination. This indicates that the independent vari ables were relatively ineffective in predicting the performance of the two player positions on the two empirically derived target scores.

The reader is referred to Ton and Kubala to allow comparison of these discriminant functions with those obtained using the AS and TS criteria. In both cases the computed discriminant functions reveal a relatively small relationship between the independent and dependent variables. However, beyond these tests, the discriminant function analysis also yields a number of indexes which may be useful in examining relationships in the data.

As an example, Table 2-6 gives the standardized discriminant function coefficients for each of the four combinations of problem type and position. Each coefficient represents the relative contribution of each independent variable to each of the four analyses (two problem types and two player positions). As an example, column 4 of Table 2-6 reveals that experience in handoff and spatial ability were relatively important in determining performance of pilot players handing off Type 2 problems.

Table 2-6. Discriminant Function Coefficients*

	Category**			
Variable	1O	1P	2O	2P
XPR	.210	-.622	.185	.932
Job	-.680	.115	-.410	.362
SF	.509	.257	.767	.405
VFF	-.097	.748	.076	.030

*Standardized coefficients.
**1O = Type 1 problem, Observer player; 1P = Type 1 problem, Pilot player; 2O = Type 2 problem, Observer player; 2P = Type 2 problem, Pilot player.

Tables 2-7 through 2-10 present additional data concerning the distribution of experience and job for the four categories. Examination of the values in Table 2-10 reveals that 88% of the successful pilot players and 91% of the unsuccessful pilot players were in fact pilots on their jobs. Hence, in this instance, the job factor has no discriminating power. However, Table 2-10 also reveals that 72% of the successful pilot players had prior handoff experience. For the unsuccessful pilot players, only 26% had prior experience, which indicates that prior experience with handoff played a role in simulator performance. A clearer picture of the relationship between successful handoff and experience will emerge by comparing the data from Tables 2-7 through 2-10 to the discriminant function coefficients (Table 2-6). From column 4 of Table 2-6, it should be apparent that experience in handoff contributes the most to success in the simulated situation (discriminant coefficient = .932). It is possible, therefore, that simple practice may be effective in handing off difficult targets.

Table 2-11 shows the means and SDs for the SF and VFF factor scores by handoff type and player role. Each of these four categories is further divided into unsuccessful and successful performers. As noted earlier, success was defined relative to the median of the factor score distribution of each of the two types of situations; i.e., unsuccessful players are those whose scores fall below the median of the distribution of scores for a given problem type. Conversely, successful players are defined as those whose scores fall above the median of the distribution of scores for a given problem type.

Table 2-7. Distribution of Job and Experience for Unsuccessful and Successful Observers and Type 1 Scores

	Category	Code	Successful Freq.	Successful %	Unsuccessful Freq.	Unsuccessful %
JOB	Pilot	0	18	78	16	67
	Other	1	5	22	8	33
XPR	No experience	0	3	17	5	23
	Experience	1	15	83	17	77

Table 2-8. Distribution of Job and Experience for Unsuccessful and Successful Observers and Type 2 Scores

	Category	Code	Successful Freq.	Successful %	Unsuccessful Freq.	Unsuccessful %
JOB	Pilot	0	15	63	19	83
	Other	1	9	37	4	17
XPR	No experience	0	5	22	3	18
	Experience	1	18	78	14	82

Table 2-9. Distribution of Job and Experience for Unsuccessful and Successful Pilots and Type 1 Scores

	Category	Code	Successful Freq.	Successful %	Unsuccessful Freq.	Unsuccessful %
JOB	Pilot	0	23	92	3	14
	Other	1	2	8	19	86
XPR	No experience	0	4	20	21	88
	Experience	1	16	80	3	12

Table 2-10. Distribution of Job and Experience for Unsuccessful and Successful Pilots and Type 2 Scores

	Category	Code	Successful Freq.	Successful %	Unsuccessful Freq.	Unsuccessful %
JOB	Pilot	0	23	88	21	91
	Other	1	3	12	2	9
XPR	No experience	0	7	28	17	74
	Experience	1	18	72	6	26

Table 2-11. Means and Standard Deviations for the Spatial and Fluency Scores by Category

Category	$\bar{x}$	σ SF	$\bar{x}$ VFF	σ VFF
10 (Successful)	.033	.894	.025	.871
10 (Unsuccessful)	-.142	.679	-.036	.914
1P (Successful)	.152	.853	.139	.775
1P (Unsuccessful)	.124	.989	-.006	.776
20 (Successful)	.209	.739	.182	.723
20 (Unsuccessful)	-.029	.822	-.169	1.006
2P (Successful)	.115	.326	.012	.907
2P (Unsuccessful)	-.277	.914	-.057	.781

As an example to demonstrate how the data of Table 2-11 may be interpreted, consider the 2P category (pilot players and Type 2 problems). In this instance, the successful performers had the higher mean (.115 vs -.277) SF scores. Referring to Table 2-6, the discriminant coefficient between 2P and SF is .408; thus, spatial ability seems to have an influence on performance for this combination of position and problem type.

The ultimate usefulness of discriminant function analysis is its effectiveness in classifying individuals into categories. The output of SPSS *Subprogram Discriminant* includes a contingency table for each category of performer which compares actual a priori classification with a classification predicted on the basis of the discriminant function. Because the groups were split at the median of the factor scores distribution time to handoff, the a priori classification would be 50% successful and 50% unsuccessful.

As can be noted from Table 2-5, the discriminant function for Category 2P performers was statistically the most successful of the four. Table 2-12 illustrates the prediction of classification obtained by using this equation. The effectiveness of the prediction can be judged by comparing the a priori and predicted group membership for each category.

Table 2-12. Prediction Results and Type 2 Scores for Pilot Players

Actual Category	No. Cases	Predicted Category Membership	
		Low	High
Unsuccessful (low score)	23	14 (61%)	9 (39%)
Successful (high score)	26	18 (69%)	8 (31%)

Thus, while low scorers were predicted at greather than chance levels (50%), the prediction of high scoring performers was less accurate. By referring to Table 2-13, it can be seen that the overall percentage correctly classified in this example is only 44.9%. Given that result, a more accurate prediction could have been made with a coin toss.

Table 2-13. Proportion of Correct Classification

Category	No. Cases*	Percent Correct Classification
Observer Player Type 1 Score	49	55.32
Pilot Player Type 1 Score	47	53.06
Observer Player Type 2 Score	49	61.70
Pilot Player Type 2 Score	47	44.90

*Unequal numbers reflect missing time data.

The most successful prediction was made for Category 20 (observers handing off Type 2 problems), but even this case barely betters chance. Hence, it must be concluded that the tests and biographical data selected for this effort have little usefulness in predicting handoff success, at least under the conditions that prevailed during the study. Replication of the study with a greater number of subjects and a larger selection of handoff situations might, however, alter this picture.

Part II: Content Analyses of the Simulated Handoffs

During the latter half of the 1976-77 contract year, tape recordings were obtained of the verbal interchange of pairs of aviators as they performed the simulated target handoffs. It was thought that careful content analyses of these interchanges would reveal the verbal behaviors which accompany effective handoff. The results of an initial analysis are reported in Ton and Kubala.[2] Due to the pressures of time,

[2] Ton and Kubala, *op. cit.*

only a small sample of handoffs could be analyzed. However, the results were promising. As a consequence, early in the 1977-78 contract year, additional content analyses were performed on transcripts of handoffs from a larger sample of performers. These analyses were simple in nature, consisting mainly of structured word counts. Other, more complex forms of content analysis were contemplated, but were rejected on the basis of the large investment of time and effort required with little guarantee of useful results. Table 2-14 supplies descriptive detail on the content analyses which were finally performed. The reader will note that the content analyses described in this report were performed on only three of the six problems used in the simulated handoffs. This reduction was indicated by the factor analysis of the times for handoff of the six problems. Inspection of Table 2-4 reveals that this analysis yielded only two factors with Factor I being almost entirely defined by Problem 3, while Factor II was defined primarily by Problem 1 with Problem 4 contributing additional variance. These data indicate that the content analysis effort would be most efficient if limited to these three problems.

These content categories were selected on the basis of the initial small-scale analyses and the findings of earlier USAF researchers; mainly, Morrissette and Crisp,[3] and Simons.[4] In addition, several content categories selected were logically related to a number of hypotheses which emerged as the work progressed. These were:

H1: Manmade features being more easily identifiable would be used more often in effective handoffs.

H2: Relative distance units would be more effective than absolute units.

H3: A high ratio of questions relative to simple acknowledgments by the pilot player would be more effective.

H4: A high ratio of adjectives relative to nouns would constitute a richer and hence more effective target description.

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[3]J. O. Morrissette and C. Crisp. *A Content Analysis of Communications Between Forward Air Controllers and Tactical Aircraft Pilots*, AMRL-TR-70-95, Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio (in process).

[4]J. C. Simons. "Landmark Logic," unpublished manuscript obtained from the author.

Table 2-14. Content Analysis

Category Label	Description
Organic terrain (O_1, O_3, O_4)	Number of organic terrain features used as reference (e.g., trees).
Natural inorganic terrain (I_1, I_3, I_4)	Number of inorganic terrain features used as reference (e.g., rocks).
Man-made (M_1, M_3, M_4)	Man-made features used as reference (e.g., house).
Relative distance units/ Absolute distance units	If either relative (half-way) or absolute (1 km) distance units were used.
Acknowledgments (A_1, A_3, A_4)	Number of acknowledgments by pilot player.
Questions (Q_1, Q_3, Q_4)	Number of questions used by pilot.
Nouns (N_1, N_3, N_4)	Number of nouns used by observer.
Adjectives (J_1, J_3, J_4)	Number of adjectives used by observer.
Target description	If description given first by observer, or later.
Total word count (Wc_1, Wc_3, Wc_4)	Total words by each stimulus pair.

The first hypothesis was suggested by careful examination of the slide pairs used as stimulus materials. This examination revealed little in the way of distinctive natural features which could be used as reference to aid in target location. The second hypothesis, favoring the use of relative distance units, was suggested by work done for the USAF by Aume.[5,6] Aume's findings indicated that relative units were more effective in performing a target location task.

The third hypothesis was based on the notion that if the pilot player only acknowledges the receipt of information, he is denying the observer player feedback as to the usefulness of the information the observer has provided. In addition, differences in perspective which add to the difficulty of handoff cannot be resolved unless the pilot provides information to the observer.

The final hypothesis conjectures that the use of a high ratio of adjectives to nouns will allow a much more precise description of the scene than a description which uses nouns only. This line of reasoning holds that if more and varied labels can be applied to the target or a reference object, it becomes more likely that the true configuration of the object will be perceived by the listener.

Table 2-15 presents summary data for the content categories which were based on word counts for the three problems. The letters in parentheses following each content category are the symbols used in the statistical analyses to represent the categories.

Table 2-16 presents frequency counts for content categories which were coded 1 or 0.

Several other content analytical schemes were proposed, but did not prove fruitful. These included a study of the use of color and the use of heading units. Perusal of the handoff transcripts revealed that color was almost never used *solely* as the primary constituent of target or terrain description. This was most likely due to the nature of the stimulus color transparencies used as stimuli, which while exhibiting good color fidelity, reflected a terrain which exhibited only small variations in hue and saturation. Hence, color was never an outstanding characteristic of the target or its surrounding.

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[5] N. M. Aume. *Estimation of Target Locations with Conventional Measurement Units*, Technical Report AMRL-TR-69-21, Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio, September 1969.

[6] N. M. Aume. *Human Ability to Estimate Target Locations with Respect to Two Points*, Technical Report AMRL-TR-69-44, Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio, November 1969.

Table 2-15. Word Counts for Selected Problems

Content Category	Problem 1 $\bar{x}$	Problem 1 σ	Problem 3 $\bar{x}$	Problem 3 σ	Problem 4 $\bar{x}$	Problem 4 σ
Organic Terrain (O)	4.94	4.01	2.53	2.20	.90	2.10
Inorganic Terrain (I)	2.77	2.56	.05	.22	.80	1.47
Man-made (M)	12.71	12.14	3.95	3.75	7.15	5.14
Acknowledgments (A)	4.33	7.22	1.68	2.24	2.20	2.19
Questions (Q)	2.77	1.99	.58	.84	.85	1.09
Nouns (N)	23.78	14.18	7.95	4.67	10.65	7.27
Adjectives (J)	10.22	7.36	3.50	2.46	5.15	4.50

Table 2-16. Frequencies for the Coded Content Categories

	Problem 1	Problem 3	Problem 4
Relative Distance Units			
1 = Used	13	12	14
0 = Not Used	5	7	6
Target Description			
Given First = 1	10	19	15
Given Later = 0	8	0	5

Regarding heading units, it was originally intended to investigate the use of relative versus absolute heading units. But the transcripts revealed that heading information was rarely used by the players. Again, this was a function of the stimulus materials and the general scenario which did not provide for any means of accurately estimating relative viewing position.

Due to technical difficulty with the recording apparatus, only a relatively small number of complete transcripts (n = 22) were available for content analysis. As a consequence, to conserve statistical power, it was decided to limit the potential number of factors wherever possible by forming composite variables. Two composite variable were formed. The first was termed a "Reply Index" and was computed for each problem by dividing the number of questions by the pilot player by the number of acknowledgments he asked. In the shorthand notation used in the tables which follow, these three Reply Indexes are labeled R_1, R_3, and R_4. Next, a "Descriptive Index" was computed for each problem. The Descriptive Index was formed for the three problems by dividing the number of adjectives used by the observer player by the number of nouns he used. Three Descriptive Indexes were thereby formed: D_1, D_3, and D_4. In addition, an attempt was made to "equalize" the word count categories dealing with type of terrain reference by dividing each mean count by the mean total word count for each of the three problems. Table 2-17 shows the final list of composite content analytical categories and the method of their formation.

It should be noted that the list of terrain reference (QA) indexes appears incomplete, lacking the index which would be formed of I_3/Wc_3 (inorganic terrain reference count divided by the word counts for Problem 3). This was due to the fact that for Stimulus Pair 3, none of the teams used inorganic natural terrain as reference in handing off the target.

To determine the relative contribution of these content analytic variables to handoff success, it was decided to use them as predictors in a series of multiple regression analyses against a criterion of time for handoff. Table 2-18 describes the structure of the three analyses performed, one for each of the three problems.

Several variables were eliminated from the regression analysis based on an inspection of frequency counts for each problem. In several instances the word count for a given category was very low or nonexistent; i.e., target description was *always* given first by *all* pairs in handing off the target of Problem 3 (Table 2-16). Hence, this factor would have zero variability and therefore no utility in prediction.

The regression analyses were performed in Alexandria, Virginia, using the ARI access to the time-shared Univac 1108 multiprocessor system. The SPSS *Subprogram Regression* was used throughout. This program provides a forward step-wise solution, which is often useful in limiting the number of predictors involved in the final regression equation.

In view of the rather small $\underline{n}$ available, it was decided to allow for the substitution of calculated values for missing data among the independent variables. Therefore, in instances where no more than 20% of the independent variables had missing values, estimated (group mean) predictors were used. This technique was chosen to avoid potential loss in statistical power due to reduced $\underline{n}$. A missing data strategy which would be varied according to the special characteristics of each predictor would have been ideal in conserving numbers. However, practical difficulties related to the characteristics of the program used prevented such a strategy. Tables 2-19, 2-23, and 2-27 show the means and SDs for the variables entered into the analyses for the three problems. Tables 2-20, 2-24, and 2-28 give the correlations between these variables. Tables 2-25 and 2-26 summarize the results of the regression analysis against a criterion of time for Problem 1. Similarly, Tables

Table 2-17. Word Count Indexes

Category/Code	Construction
Reply Indexes	
R_1	Q_1/A_1
R_3	Q_3/A_3
R_4	Q_4/A_4
Descriptive Indexes	
D_1	J_1/N_1
D_3	J_3/N_3
D_4	J_4/N_4
Terrain References	
QA_1	O_1/Wc_1
QA_2	I_1/Wc_1
QA_3	M_1/Wc_1
QA_4	O_3/Wc_3
QA_5	M_3/Wc_3
QA_6	O_4/Wc_4
QA_7	I_4/Wc_4
QA_8	M_4/Wc_4

Table 2-18. Structure of the Three Regression Analyses

Analysis	Predictor Variable Code	Description
Problem 1		
X_1	QA_1	Organic Terrain
X_2	QA_2	Inorganic Terrain
X_3	QA_3	Man-made Terrain
X_4	B	Relative distance units
X_5	R_1	Reply Index 1
X_6	D_1	Descriptive Index 1
X_7	G^1	Target Description 1
Y_1		Criterion (Time)
Problem 3		
X_1	QA_4	Organic Terrain
X_2	QA^4	Man-made terrain
X_3	D 5	Relative Distance Units
X_4	R_3	Reply Index 3
Y_3		Criterion (Time)
Problem 4		
X_1	QA_6	Organic Terrain
X_2	QA_7	Inorganic Terrain
X_3	QA_8	Man-made terrain
X_4	F	Relative Distance Units
X_5	R_4	Reply Index 4
X_6	D_4	Descriptive Index 4
X_7	I	Target Description 4
Y_4		Criterion (Time)

2-27 and 2-28 summarize the regression results for Problem 3, and Tables 2-29 and 2-30 for Problem 4.

In all three analyses, the program was allowed to progress stepwise until the gain in accountable variance with subsequent steps was nearly zero. This strategy was chosen to clarify the pattern of causation betwen the predictors and the criterion variable. For each equation, only the first few predictors contribute reliably to the multiple correlation. For Problem 1, G (target description) accounts for the most variance, followed by QA_1 (use of organic terrain in target description), and finally, B (use of absolute distance units). Addition of the remaining three predictors causes the standard error of regression to become too large to permit reliable prediction. For Problem 4, F (use of absolute distance units) was entered first, followed by QA_6 (use of organic terrain as reference). After this point no gain in reliability could be obtained by adding the remaining predictors. For Problem 3, QAS (use of man-made features as reference) was the strongest predictor, followed by R_3 (the Reply Index).

The results seem to indicate a high degree of stimulus specificity in that a different strategy seems to be required to handoff each problem. This is unfortunate as the number of realistic problems in the "real world" handoff situation is enormous. Consequently, it would be extremely difficult to design a study to ascertain the basic set of common rules which would lead to success in handing off targets. The population of possible handoff situations is likely to be so large that even this modest goal would be frustrated.

The current study does give indications that support the formulation of a few rules; i.e., the findings tend to support the conclusion that a more rapid handoff will occur if the target is named early (or initially), if relative distance units are used, and if care is exercised in selecting the appropriate terrain features for use as reference to target location. The choice of appropriate reference seems to depend on the characteristics of the salient features in the terrain, and again, the question of which to use becomes determined by the multitudinous characteristics of the handoff situation.

However, beyond these few general results, it can be said that the findings of the present study have a rather low degree of generalizability to any given handoff situation. However, it is possible that improved performance in target handoff could be achieved by a general training strategy. Evidence for this can be found in the generally superior performance in the simulated situation of individuals with handoff experience. Such a training strategy would provide intensive practice over a wide range of handoff situations. This would allow the individual aviator to gain a good deal of general practice in handoff economically and might allow the formation of strategies which would result in improved performance in the field. Subsequent chapters in this report will detail how these notions were pursued during the third year of handoff research.

Table 2-19. Means and Standard Deviations of Regression Factors for Problem 1

Variable	Mean	SD	n*
T_1**	165.400	80.378	20
QA_1	.037	.031	21
QA_2	.060	.152	21
QA_3	.132	.137	21
B	.722	.461	18
R_1	.782	.719	21
D_1	.548	.324	21
G	.556	.511	18

*N = cases with complete transcripts.
**Criterion.

Table 2-20. Correlation Coefficients for Problem 1

	T_1	QA_1	QA_2	QA_3	B	R_1	D_1	G
T_1	1.000	.233	-.070	.117	.067	.100	.021	.607
QA_1		1.000	-.093	-.284	-.040	.229	.441	.151
QA_2			1.000	.936	.200	-.206	.124	.217
QA_3				1.000	-.267	-.153	.099	.310
B					1.000	-.040	-.328	-.091
R_1						1.000	.355	.252
D_1							1.000	-.019
G								1.000

Table 2-21. Obtained Multiple Correlations for Problem 1

Variable Added	Multiple R	R^2	R^2 change
G	.607	.369	.369
QA_1	.624	.389	.020
B	.636	.405	.016
R_1	.642	.412	.007
QA_2	.650	.423	.011
D_1	.657	.432	.010

Table 2-22. Regression Equation for Problem 1

	B	Beta	SE B	F
G	108.983	.693	44.242	6.068*
QA_1	261.797	.100	747.945	.123
B	36.017	.201	49.136	.537
R_1	-19.340	-.173	32.888	.346
QA_2	-87.812	-.166	156.096	.316
D_1	34.594	.140	84.461	.168
(constant T_1)	70.545			

*$p < .05$.

Table 2-23. Means and Standard Deviations for the Variables Used in the Analysis for Problem 3

Variable	Mean	SD	n*
T_3**	73.105	71.384	19
QA_4	.053	.032	21
QA_5	.074	.041	21
D	.632	.496	19
R_3	.386	.648	21
D_3	.488	.249	21

*N = cases with complete records.
**Criterion

Table 2-24. Correlation Coefficients for Problem 3

	T_3	QA_4	QA_5	D	R_3	D_3
T_3	1.000	.322	.589	.215	.326	.123
QA_4		1.000	.588	.199	.655	.352
QA_5			1.000	.277	.441	.326
D				1.000	.043	.057
R_3					1.000	.301
D_3						1.000

Table 2-25. Obtained Multiple Correlations for Problem 3

Variable Added	Multiple R	R^2	R^2 change
QA_5	.589	.347	.347*
R_3	.594	.352	.005
D_3	.600	.360	.008
QA_4	.604	.365	.005
D	.608	.370	.005

Table 2-26. Regression Equation for Problem 3

Variable	B	Beta	SE B	F
QA_5	1039.673	.594	495.755	4.400*
R_3	18.044	.164	32.668	.305
D_3	-23.321	-.081	68.586	.116
QA_4	-266.032	-.120	730.612	.133
D	10.300	.072	33.397	.095
(constant)	7.967			

*$p < .05$.

Table 2-27. Means and Standard Deviations for the Variables Used in the Analysis for Problem 4

Variable	Mean	SD	n*
T_4	65.632	41.088	19
QA_6	.012	.024	21
QA_7	.017	.300	21
QA_8	.113	.073	21
F	.300	.470	20
R_4	.392	.686	21
D_4	.488	.307	21
I	.750	.444	20

n = cases with complete transcripts.

Table 2-28. Correlation Coefficients for Problem 4

	T_4	QA_6	QA_7	QA_8	F	R_4	D_4	I
T_4	1.000	.392	.047	.078	.510	.066	.026	-.266
QA_6		1.000	.490	-.213	.256	.080	.167	-.123
QA_7			1.000	-.069	-.180	.182	.644	.039
QA_8				1.000	.079	.102	-.251	.368
F					1.000	.432	.118	-.378
R_4						1.000	.236	-.388
D_4							1.000	.233
I								1.000

Table 2-29. Obtained Multiple Correlations for Problem 4

Variable Added	Multiple R	R^2	R^2 change
F	.510	.260	.260
QA_6	.577	.333	.073
QA_8	.604	.364	.031
R_4	.633	.401	.036
QA_7	.636	.404	.003
D_4	.637	.406	.002
I	.638	.407	.001

Table 2-30. Regression Equation for Problem 4

Variable	B	Beta	SB E	F
F	51.151	.585	31.820	2.584
QA_6	412.962	.244	583.850	.500
QA_8	104.127	.185	152.974	.463
R_4	-15.026	-.251	17.441	.742
QA_7	172.545	.124	653.522	.070
D_4	-6.741	-.050	54.204	.015
I	-3.413	-.037	28.876	.014
(constant)	42.409			

Chapter 3

DESCRIPTION OF THE STUDY

The findings of the research described in Chapter 2 indicated that the first priority for pursuing further handoff research was the development of a relatively large number of simulated handoff problems that could be presented to pairs of helicopter pilots. Prior experience had shown that attempts to photograph real vehicles in terrain are time-consuming and costly. In addition, it was felt that considerable realism with a consequent increase in subject motivation could be gained by using threat (Warsaw Pact) vehicles in the handoff problems. Studies of tactics projected for a possible European conflict had further indicated that a likely Soviet tactic would be rapid infiltration of friendly territory to preclude the use of tactical nuclear weapons by NATO forces. Thus, in this hypothetical situation, the pilot of an Attack Helicopter (AH) would be faced with a target-rich environment in which he must correctly discriminate the higher priority target as designated by the scout. The quest for realism also dictates that the target be portrayed at a realistic engagement range; i.e., 2000 to 3000 meters. Each set of stimuli for the simulator problems must then provide the two players with views of terrain containing a mix of threat and friendly vehicles at a realistic engagement range. As in the previous work with target handoff, the range, viewing altitude and bearing of the target must be varied between the two views. Obtaining imagery which would meet all of these specifications is obviously a considerable technical challenge. This challenge was compounded by the desire to present the pairs of players in the simulation a large number of target handoff problems. The increased number of problems were necessary to allow the players extensive practice and also to permit a more powerful analysis of the nature of the handoff task itself. As 35mm slides had proved satisfactory in the previous work, this format was adopted for all subsequent problems.

The projected images of armored vehicles at realistic engagement ranges were quite small. A review of Army recognition training literature revealed that there was no existing program for the recognition of targets at long range. Hence, it was decided that the projected extensive practice in simulated handoff would be effectively supplemented by training in long range target recognition. This decision provided the impetus for the development of an armored vehicle recognition training slide kit.

Production of the Imagery

The initial issue to be addressed was the selection of a method for the generation of recognition slides and handoff imagery. As structured for the present work, the handoff problems required that an observer player and an attacker player be presented with two different views of the same target area so that the observer could handoff a target to the attacker. In the interests of realism it was decided to present the attacker with a second "closer" view of the target so that he could identify the type of vehicle. This second view was intended to duplicate the appearance of the target as it would appear through a high power optic. In the "real" combat situation such an optic would be available to the AH pilot and would be used for verification of the target. Therefore, each handoff problem required three slides to present the required imagery: an observer target area view, an attacker target area view, and an attacker target close-up.

Imagery For Handoff

The simulation of handoff is difficult because the attacker and the observer have different views of the target area. Each may see targets not seen by the other. Therefore, it was felt that good handoff problems should exhibit some element of confusion. Several scenarios were developed. These are stated by the following examples.

1. The observer sees a single target, but the target is hidden by foliage in the attacker's view so that he must determine the location of the target.

2. The observer sees multiple targets, and designates a specific target. The attacker only sees some of the targets and must determine which one the observer is designating.

3. The observer and the attacker have a nearly identical view of a partially hidden target. The attacker's view is seen from much farther away so that the target is harder to detect.

4. The observer mistakenly designates a friendly vehicle as a target. It is up to the attacker to assess the situation and determine if the target should be engaged.

5. A group of enemy vehicles is spotted, including tanks and antiaircraft weapons. The observer designates a tank as the target. The attacker must then decide which target to hit.

6. Two groups of vehicles, similar in appearance, are seen. One group is an enemy and the other is friendly. The attacker must identify the enemy group.

7. The observer has spotted a partially hidden vehicle, but cannot tell that it is an enemy. He asks the attacker, who is in a better position to help him identify the target.

Other variations could be developed. Camouflaged targets could be used as could targets other than armored vehicles such as artillery emplacements. The seven basic scenarios were used to develop 27 observer-attacker handoff problems. The development of problems to suit these scenarios was found to be quite difficult. However, considerable experimentation revealed that the visual stimuli required for the problems could be provided by a photo montage technique. As finally developed, this technique proved to be an excellent means of economically presenting a variety of targets emplaced in terrain. An additional important advantage of the montage technique is the realism of the images provided. Appendix A contains the details of this method.

The Recognition Slide Kit

The kit, composed of 96 slides, had as its primary objective the training of pilots to recognize, at long range, 13 different armored vehicle types. Table 3-1 lists the vehicles that were trained. The slide kit was designed to be shown to the students individually, or in small groups, using a Singer Caramate II slide viewer. The Caramate has a 9-inch square screen and provides a sharp, bright image. The built-in cassette recorder provides the narration and slide synchronizing pulses.

Table 3-1. Vehicles Contained in the Recognition Slide Kit

Origin	Model	Type
US	M60	Tank
US	M551	Sheridan Tank
US	M113	APC
US	M109	SP Howitzer
British	Chieftain	Tank
British	Scorpion	Reconnaissance Vehicle
German	Leopard	Tank
German	Gepard	Antiaircraft System
Soviet	T-62	Tank
Soviet	T-54/55	Tank
Soviet	BTR-60P	Personnel Carrier
Soviet	ZSU-57	Antiaircraft Gun

It was decided that each vehicle could be presented using no more than 10 slides. However, the lessons for some of the more well-known or unique vehicles required only six of seven slides. Since helicopter pilots would usually see the vehicles from a distance, there was no concern about teaching small recognition features. One or two key recognition features were identified for each vehicles that could be seen at a distance. For example, it was found that the exhaust vents located on the rear sides of the German Leopard tank were usually recognizable when other features such as the tank's seven roadwheels were still indistinct.

A typical lesson started out with two closeup slides of an HO gauge vehicle model taken at angles of 45° and 90° as shown in Figure 3-1. Arrows were used to point out the key features and a title block at the top of the slide gave the name or model designation of the vehicle, the country of origin, and a silhouette of the vehicle. The accompanying narration explained the key recognition features and gave any anecdotal information that might help the student learn to recognize and remember the vehicle.

Slides 3, 4, and 5 of the typical lesson presented actual photographs of the vehicle. Here again, the key features were stressed by the narration, and variations in other appearance factors were pointed out such as the presence or absence of searchlights, fender skirts, etc. These first few slides were copies of photos of actual equipment found in recognition journals, manuals, or other publications in which pictures of armored vehicles could be found. Some lessons contained slides showing similar vehicles that might be confused with the vehicle being taught.

Slides 6, 7, 8, and 9 were views of four to six vehicles that included the vehicle being trained and other vehicles similar in appearance and function. These slides were either of models against a white background or were montage slides as shown in Figure 3-2. For each of these slides, the student was asked to identify the vehicle being trained, as well as any others that he could learn incidentally. The narration provided feedback by naming all of the vehicles in the slide. Therefore, at least half of each lesson was devoted to testing on the vehicle being trained as well as review of previous vehicles trained and incidental learning of new vehicles.

Thirteen lessons were developed to train the subjects to identify the 13 vehicles listed in Table 3-1. The prototype slide kit consisted of 96 slides. The 80-minute narration was contained on two 120-minute (C-120) cassettes. (Note that a C-120 cassette can only contain 60 minutes of narration as the other track contains the synchronizing pulses.) Based on these figures, each vehicle required about 6.15 minutes of training time. Therefore, material for training 18 vehicles could be put in a standard 140-slide tray using two C-120 cassettes for the narration.

The Improved Handoff Simulator

Two rear projection consoles (see Figure 3-3) were built for the presentation of the observer and attacker slides. Each console had a 13 x 20 inch "polacote" display screen. Each of the screens was fitted

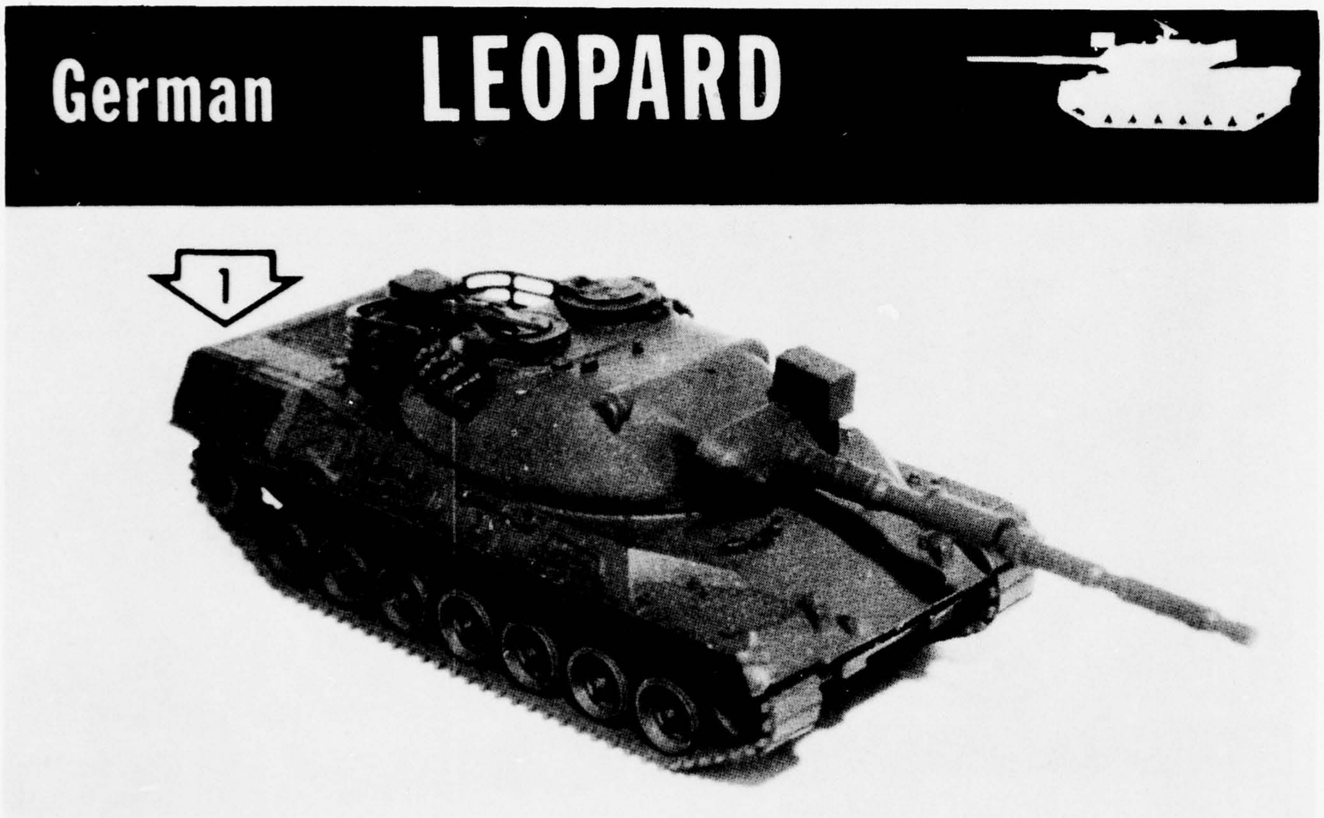

Figure 3-1. Initial frame for German Leopard recognition lesson.

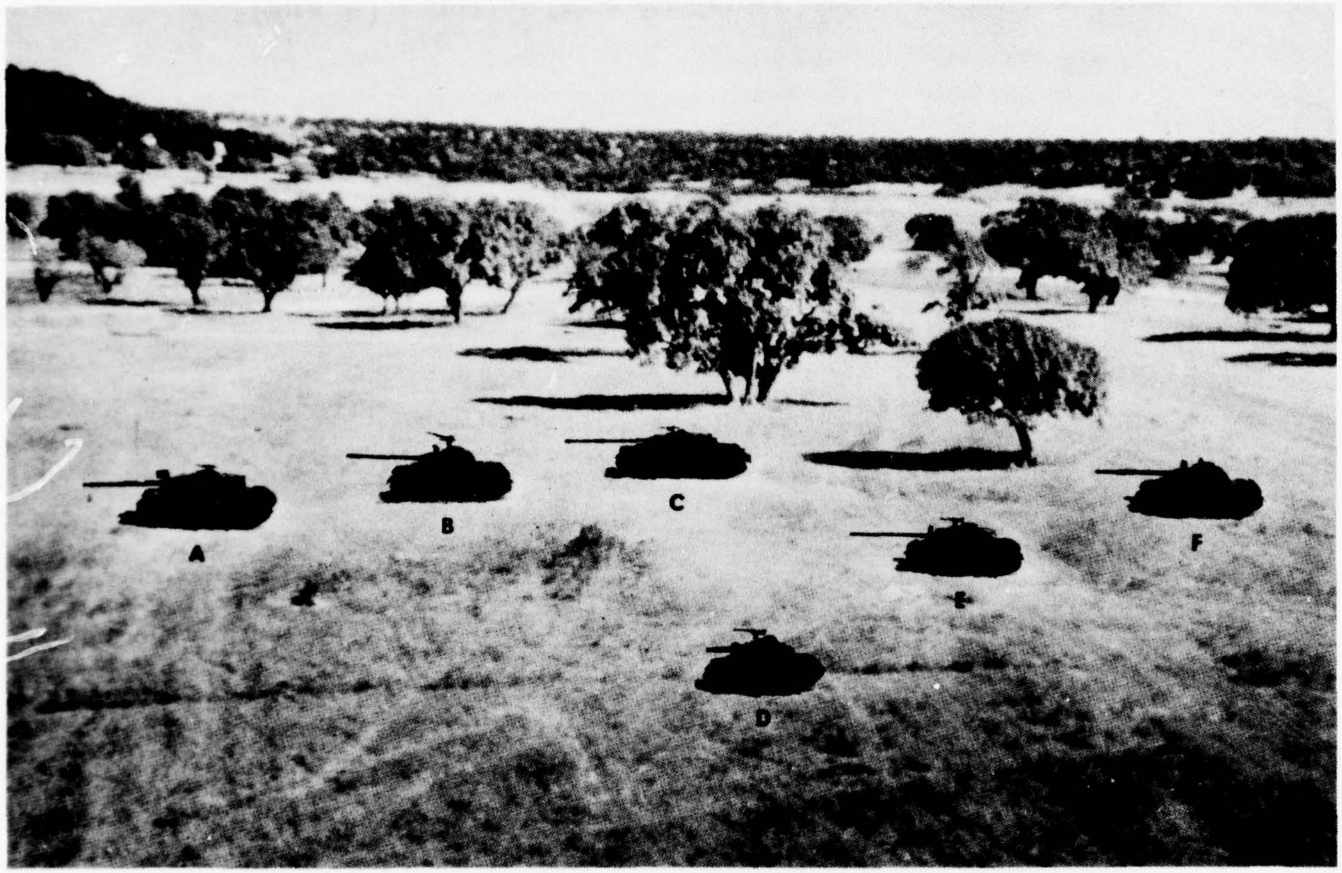

Figure 3-2. Sample examination test frame.

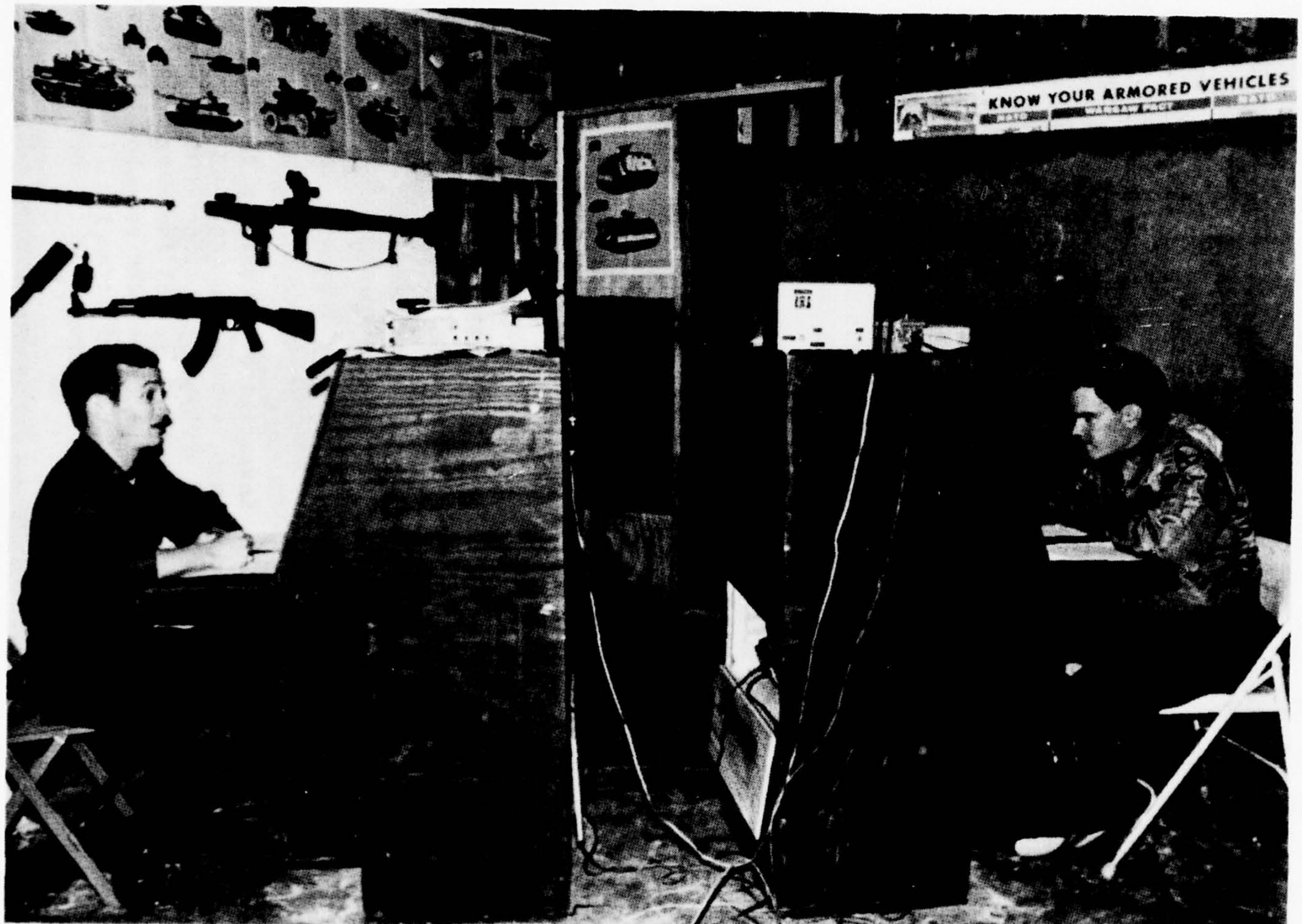

Figure 3-3. Handoff simulation consoles.

with a clear plastic grid containing 20 squares arranged in a 5 x 4 array. The observer was provided with a booklet which gave a grid with an "X" marking the target location for each problem. The observer then used the overlay grid to locate the target.

The slides were presented in the following manner. The test monitor started each cycle; the observer then had 10 seconds to familiarize himself with the view and locate the target. At the end of that time the attacker's slide was presented and the handoff dialogue could begin. Forty-five seconds were alloted for the attacker to correctly locate the target vehicle. Fifty-five seconds from the start of the cycle the observer's screen went blank and the attacker was presented with a closeup view of the target vehicle. The attacker was alloted 10 seconds to correctly identify the vehicle. The total time alloted for each problem was 65 seconds.

The slide projectors were controlled by an electronic programmer specially built to give the required timing. The test monitor simply pressed a switch to start the cycle. The timer would change observer slides at 0 and 55 seconds, and attacker slides at 10, 55, and 65 seconds. At the end of the cycle the timer reset to 0 and was ready for the next start command. A logic diagram of the timer is shown in Appendix B.

Design of the Study

Subjects

Subjects were Army personnel drawn from the 6th ACCB, Fort Hood, Texas. Since the subjects were to be run in pairs it was requested that each pair consist of an AH pilot and a scout pilot. An enlisted crew chief or observer could be substituted for the scout pilot as these individuals had received training in airborne reconnaissance. Sixty pairs of subjects were initially requested.

Experimental Design

The intent of the study was to investigate the effects of experience in simulated handoff and long range recognition training on handoff performance. It became obvious rather early in the study that it would not be feasible to validate the training by an actual field exercise. As a result, 10 of the simulated handoff problems were selected to serve as a criterion test. These were selected randomly from the 27 problems. An additional two were similarly selected to serve as introductory orientation problems.

Subjects were randomly assigned into four groups as follows:

Group 1. Recognition training followed by 15 handoff problems then the 10 criterion problems.

Group 2. Recognition training then the 10 criterion problems.

Group 3. Fifteen handoff problems then the 10 criterion problems.

Group 4. Criterion problems only.

The experiment therefore took the form of a simple randomized block design. This design would allow assessing the relative effectiveness of the two experimental treatments--handoff practice and recognition training--as well as the effectiveness of both in combination. The criterion test only group (Group 4) would serve as a baseline or control.

Procedure

The study was carried out in space provided by the 6th ACCB. As the pairs of subjects arrived, they were first briefed on the objectives of the study and the activities in which they would be participating. Each subject was also asked to fill out a very brief biographical information sheet (Appendix C).

The recognition training was totally self-contained and subjects required no instructions beyond a general orientation before receiving the training. They were then seated in front of the Caramate and the device was started. The program required approximately 80 minutes. Following the recognition training the subjects were familiarized with the handoff simulator.

Before being seated at the simulator, each pair of subjects was given instructions appropriate to the position he would be playing. These instructions are included as Appendix D. Questions were then answered concerning the conduct of the experiment. The subjects were provided with booklets which reproduced in smaller form the grid overlay on their screens, one for each problem. The observer, or scout player, was provided with coordinates and a large "X" in the appropriate grid which served to mark the target he was to describe. The attacker player's booklet contained a similar grid and he was to note his estimate of target location by placing an "X" in the appropriate grid square. A line was also provided for him to write in the name of the target vehicle from the second, closeup slide. The consoles were placed in close proximity back-to-back so that neither subject could see the other's screen.

A voice communications system was developed for the simulator. However, it was not used in this study because low ambient noise level in the experimental area permitted conversational speech. In addition, the communications system would not permit the experimenter to talk to either subject independently. It was felt that the potential for confusion outweighed the advantages of a closed communications system.

The subjects were then seated at their respective consoles and given two practice problems. At the conclusion of each problem the subjects were allowed to view each other's screens and the experimenter answered any questions that were posed.

Following the two practice problems, the remaining problems were run, each presentation taking 65 seconds with a minimum interval between each problem. Thus, the full set of problems required about 35 minutes for completion. After the criterion problems, the subjects were debriefed and allowed to review as many problems as they wished. They were then thanked for their cooperation and allowed to return to their units.

Chapter 4

RESULTS

Method

The attacker test booklets were examined and each problem scored right or wrong. Because each handoff problem had a location aspect as well as a target identification aspect, each subject pair received two scores--one for location, another for identification. These scores were computed only on the criterion problems and thus ranged from 0 to 10. The scores for the 15 practice problems were retained for the purposes of subsequent item analyses. Location scores, identification scores, and selected items of biographical data were then transferred to IBM general purpose data coding forms. These were used to generate a deck of punched cards for data entry into the computer. A sequential numeric code was used to identify each pair of subjects. To safeguard the privacy of each subject, names and SSANs were not used. The analyses reported were carried out with the SPSS package of programs. The analyses were done at ARI/Alexandria using their time-shared access to a Univac 1108 multiprocessor system.

Description of the Sample

Although 60 pairs of subjects were initially requested, it soon became apparent that the constraints inherent in conducting a study with an operational military unit were going to reduce the number of subjects available from the desired population. It was therefore decided to settle for 12 pairs of subjects per group which would involve 48 pairs total. The final distribution reflected further attrition and was as follows:

Group 1 (recognition training, handoff practice, criterion test), 12 pairs;
Group 2 (recognition training, criterion test), 11 pairs;
Group 3 (handoff practice, criterion test), 11 pairs;
Group 4 (criterion test only), 10 pairs.

Overall, the sample had a mean age of 27.98 years, with 6.05 years of military service. They also reported a mean of 12.05 months in their present job. Table 4-1 gives a breakdown by experimental group of the rank, and where appropriate, the primary MOSs of the individual participants in the study.

The officer subjects were all aviators who had experience as pilots of both observation and AH aircraft. The enlisted men were crew chiefs and observers, all with aerial reconnaissance training. Of the warrant aviators, the 100Q and 100B MOS are primarily scouts, while the 100E are AH pilots.

Table 4-1. MOS by Experimental Group

Group	Enlisted	Warrant Officer Pilots 100Q	100E	100B	Officer
1	0	2	16	4	2
2	0	0	13	8	1
3	2	0	0	11	9
4	5	0	5	5	5

The factor of prior handoff experience was of interest and considerable variability was present in the subject population. Based on previous experience, there was reason to doubt absolute estimates of handoff experience, therefore, this variable was reduced to three categories; i.e., both players reporting experience, one player reporting experience, and neither player reporting experience. Table 4-2 summarizes this data.

Table 4-2. Experience by Experimental Group*

Group	Both Experienced	One Experienced	Neither Experienced
1	9	1	2
2	4	4	2
3	3	7	1
4	1	4	5

*The row totals do not add to n due to missing data.

Location and identification scores. As noted earlier, each pair of subjects received two criterion scores--one for location, a second for identification. Table 4-3 gives summary information for the two scores by the groups. Examination of these data reveal that the groups with practice in location (1 and 3) exhibit slightly higher location scores than the groups without practice (2 and 4). As expected, the results for the identification score are more dramatic. The groups who received long range recognition training (1 and 2) had considerably higher identification scores than those who did not receive this and training (3 and 4). The statistical significance of these differences will be explored later. The overall correlation between the location and identification scores was small (r = .112).

Table 4-3. Means and Standard Deviations for the Criterion Scores

Group	Location $\bar{x}$	Location σ	Identification $\bar{x}$	Identification σ
1	6.333	1.557	9.500	.674
2	5.455	1.809	8.900	.831
3	6.272	1.191	3.272	2.796
4	5.100	.482	3.200	1.989

Characteristics of the criterion problems. For each problem the total number correct was tallied for each group. This is given as percent correct (*p*) for each problem by Table 4-4.

Table 4-4. Percent Correct by Group for the 10 Problems of the Location Criterion Test

Group	n	Problem Item 1	2	3	4	5	6	7	8	9	10
1	12	92	100	92	50	33	58	00	58	67	83
2	11	64	82	91	55	18	64	00	27	45	91
3	11	82	82	82	64	27	64	00	55	73	91
4	10	60	60	80	60	20	40	10	40	60	80

These *p* values show that some problems, particularly No. 7, were poorly chosen for inclusion in the criterion test. No. 7 adds nothing to the variability of the scores, while some of the others add very little. However, across all 10 problems, the poor performance of the control group (4) is apparent. Appendix E gives the *ps* for all 25 problems. Examination of these values indicate that there are problems which would have been better choices for the criterion test and that there are problems which should be deleted. However, due to time and sample limitations, it was not possible to determine these problem characteristics prior to the study. These data are therefore offered as guidance for future work.

Table 4-5 gives the *p* values for the identification problems in the identification criterion test.

Table 4-5. Percent Correct for the 10 Problems of the Identification Criterion Test

		Problem									
Group	n	1	2	3	4	5	6	7	8	9	10
1	12	100	100	100	92	100	100	92	100	92	75
2	11	81	91	91	82	82	100	64	100	100	100
3	11	91	27	55	18	91	55	27	27	36	64
4	10	100	30	50	30	10	60	20	10	30	70

The identification problems present a better picture of discrimination than the location items, with the exception of Problem 1. Long range target identification is clearly inferior in the untrained groups (3 and 4).

Phi (ϕ) coefficients were then computed between the problems of the criterion test to give some notion of the pattern of relationship existing within the criterion test. Table 4-6 gives these coefficients.

Examination of these coefficients presents a picture of very sparse relationship(s). Only one tabled value reaches accepted levels of significance. Chance alone at Alpha = .05 would lead to an expectation of approximately two significant correlations. As a consequence, this single significant coefficient can probably be safely ignored. The picture of low relationship between problems is similar to that reported in the earlier work. Appendix F contains the ϕ coefficients between the other 15 location problems showing a similar pattern of low relationship.

Table 4-6. Correlations Between the 10 Criterion Problems of the Location Criterion Test

	1	2	3	4	5	6	7	8	9	10
1	1.000	.272	.077	.027	.212	.080	.260	.106	.027	.229
2		1.000	.016	.173	.136	.173	.106	.161	.110	.016
3			1.000	.055	.077	.213	.155	.036	.093	.228
4				1.000	.291	.019	.128	.126	.345*	.188
5					1.000	.027	.052	.105	.242	.077
6						1.000	.054	.058	.032	.055
7							1.000	.066	.215	.107
8								1.000	.162	.037
9									1.000	.229
10										1.000

*$p < .05$

Table 4-7 gives the ϕ coefficients between the 10 problems comprising the identification criterion test. Among the identification problems the overall picture is quite the opposite of that presented by the location problems. This result is probably due to the effectiveness of the recognition training which allowed trained subjects to identify virtually all of the vehicles.

Table 4-7. Correlations Between the 10 Problems of the Identification Criterion Test

	1	2	3	4	5	6	7	8	9	10
1	1.000	.602*	.604**	.549**	.727**	.305	.453**	.737**	.657**	.133
2		1.000	.436*	.771**	.507**	.436*	.507**	.662**	.652**	.154
3			1.000	.450**	.499**	.488**	.394*	.620**	.471**	.188
4				1.000	.545**	.394*	.361*	.627**	.631**	.293
5					1.000	.418*	.636**	.830**	.561**	.242
6						1.000	.305	.523**	.230	.128
7							1.000	.644**	.369*	.241
8								1.000	.709**	.349
9									1.000	.296
10										1.000

$*p < .05$
$**p < .01$

The next step in the analysis was to statistically test the effectiveness of the treatments in improving performance on the criterion tests. Multiple regression analysis was used to explore the relationship between the treatments (as represented by the four groups) and the two criteria of location and identification.

Dummy coding was employed to represent the treatments (groups) as independent variables in multiple regression. This technique is highly flexible and tolerant of unequal n's as encountered in the present study. The SPSS *Subprogram Regression* was used in this analysis. Table 4-8 gives the overall multiple correlation (R) and the contribution of each of the experimental treatments in predicting the location criterion score.

As can be seen from Table 4-8, Conditions 1 and 3, in which the subjects received all 25 handoff problems are most effective in improving handoff performance. Reference to Table 4-3 gives the means for Group 1 (recognition training and handoff practice) and Group 3 (handoff practice) are larger than Group 2 (no practice) and Group 4 (criterion test only). The significance of the differences between Groups 1 and 3 was then assessed by Sheffe's test. This test showed that the difference between the means of Groups 1 and 3 was not sufficient to reach accepted levels of significance. This finding indicates that practice alone would be the most efficient means of improving location criterion test performance.

Table 4-8. Regression Analysis of the Location Data
($R = .337^*$, $n = 42$)

Variable Entered	ΔR^2+	Simple r
Group 1	.078*	.203
Group 2	.006	-.135
Group 3	.067*	.169

+ = increase in R^2 when the variable was entered last.
*$p < .05$

Table 4-9 details a similar analysis carried out on the identification criterion test scores.

Table 4-9. Regression Analysis of the Identification Data
($R = .821^{**}$, $n = 42$)

Variable Entered	ΔR^2+	Simple r
Group 1	.416**	.559
Group 2	.328**	.427
Group 3	.000	-.519

+ = increases in R^2 when the variable was entered last.
** $p < .01$.

Table 4-9 shows that the conditions which exposed the subjects to recognition/identification training contributes the most to identification performance. The means shown in Table 4-3 further substantiated that the recognition training was highly effective in improving the performance on the identification criterion test. In this case, Sheffe's test shows that Group 1 (handoff practice and recognition training) was not superior to Group 2 (recognition training only), indicating that the handoff practice does not significantly add to the effectiveness of the recognition training.

Additional analyses explored the relationship between experience in handoff and performance in the simulation situation. The results showed no relationship between experience (coded as in Table 4-2) and location score. However, the Multiple R between experience and the identification was .346 ($p < .01$), with the pairs composed of two experienced individuals being superior in identification performance.

Chapter 5

SUMMARY AND CONCLUSION

The research described in this report was concentrated around four major activities. These were:

- Content analyses of verbal exchanges between individuals performing simulated handoffs.
- The development of a large number of simulated handoff problems.
- The development of a training package for long range target recognition.
- The evaluation of recognition/identification training and simulated handoff practice.

The content analyses were expected to yield much useful information, but the final results were disappointing. Briefly, the findings indicated that it would be extremely difficult to develop a set of general rules which would improve performance in target handoff. In fact, it was judged likely that each handoff situation would require a unique set of rules. Finally, in view of the probably infinite number of different handoff situations, the generation of a complete set of rules would be clearly beyond the scope of the current effort.

It was felt that the most effective solution to enhancing handoff performance was to provide a means whereby aviators could receive intensive practice in a wide variety of situations. A method of providing accumulated practice in handoff had been developed as part of the research. A refinement of this cumulation was used as a system test bed in the current research. It was also decided that the handoff scenarios should take into account potential aggressor tactics and reflect the current rules of engagement as determined by the characteristics of current weapons systems. These needs dictated that initial priority be directed toward the development of a technique generating a large number of realistic handoff problems. Secondly, because the realistic handoff problems would feature a "mix" of threat and friendly vehicles at long range, it was necessary to devise a training package to develop long range target recognition skills.

The difficulties involved in producing imagery for the long range recognition/identification training and the handoff problems were solved by the development of a photo montage technique. This technique permits the economical preparation of 35mm transparencies which contain views of threat and friendly vehicles emplaced in terrain. When projected, these transparencies yield an image that was judged highly realistic. Twentyseven sets of problems were developed; each problem consisted of three transparencies, one for the observer player and two for the attacker player. The observer and attacker simultaneously viewed a target area from a differing perspective. The attacker's task was to locate the target using the observer's information. The attacker then received a second, closer view of the target to allow him to identify it.

To properly utilize the improved imagery, a handoff simulator was constructed consisting of two rear-projection consoles, each containing its own projection system. The consoles were linked together by a programmer specially constructed for this research. The programmer provided the proper sequence of events for both consoles. A communications set was also designed and built for the simulation. This device would allow the two players to exchange information and would allow recording of the handoff. To cut cost and procurement time, the communications equipment used standard issue headsets with push-to-talk switches.

The handoff simulation and recognition training were evaluated in a study which used experienced Army personnel as subjects. Forty-four pairs of subjects were randomly assigned into four treatment groups. This design would allow assessment of the effects of the independent handoff practice and recognition/identification training as well as their combined impact. Members of each pair were then assigned to play either an AH pilot or a scout pilot in the simulation. This assignment was done on the basis of the subjects' actual military assignment. All subjects received a criterion test of 10 problems. Each problem was scored pass or fail. This test yielded a location score and an identification score. Analyses were carried out separately for location and identification as the correlation between the two criterion scores was very small. The results of this study showed that handoff practice in the simulated situation resulted in improved performance on the criterion performance test. The observed relationships were small but reliable. The study also revealed that the recognition training resulted in greatly enhanced ability to identify armored vehicles when seen at tactical ranges under simulated conditions. The effects of recognition training on handoff was minor and not statistically significant.

Selected item statistics were computed on both practice problems and problems in the criterion set. This analysis showed that several of the location problems had poor psychometric characteristics; i.e., were either too difficult or too easy. Several of the problems selected for the criterion test were far from ideal in this respect. When the problems were analyzed for identification scores, the picture was improved. Correlations between the problems based on location scores showed that the problems were largely independent of one another; i.e., small, near zero correlations were prevalent. The identification scores on the sample problems, however, were highly correlated, indicating that there may be "families" of identification problems; however, further analyses will be required to determine if such a structure in fact exists.

In summary, the evidence from the current study indicates that simple practice in handing off targets over a wide range of situations results in enhanced performance, at least under the conditions of the study. The increase in handoff performance obtained under these simulated conditions was small but reliable. It is entirely possible that if the study were to be redone with a new sample of subjects and replacement of several of the problems that the improvement would be greater. The program of long range recognition training proved highly effective in improving target identification skills, but had little impact on handoff performance.

Recommendations

As noted above, the set of problems used in the simulation contained a number of items with poor psychometric properties. Therefore, the first order of business should be elimination of these and development of substitutes. Secondly, the factor of experience in handoff was unevenly distributed over the experimental groups and may have influenced the results. This factor should be investigated further, perhaps by analysis of covariance.

The recognition training appears to be, at least under the test conditions, a highly effective means of training the ability to identify targets at long range. Study of existing Army training and discussion with the personnel of the 6th ACCB point out that this training is highly appropriate for rotary wing aviators and scouts, but such a training package is currently lacking from the Army's curriculum. Therefore, a considerable service might be rendered by extension and dissemination of the armored vehicle recognition slide kit.

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APPENDIX A

PREPARING THE MONTAGE SLIDES

Both the training slide set and the handoff simulator required imagery that showed a variety of armored equipment, including Warsaw Pact vehicles. Considerable study revealed that the most economical way to obtain the required views was to construct montage slides by superimposing views of models onto real terrain scenes. The basic procedure for making the montage slides was as follows: Slides of terrain were projected on a screen; black and white photographs of tank models were then placed on the projected background so that they appeared to be a part of the scene. The projected image with the superimposed photographs was then photographed using color transparency film. Although this technique had its limitations, it was found that the final product was very realistic. In fact, slides produced with this technique appear more realistic than those of models photographed on sandtables.

Terrain Slides

One of the constraints of the montage technique is that the background slides must have open areas of light color such as grassy areas or areas of bare earth in which the model photos can be placed. If the model photos were placed in an area that contained bushes or other detail, then that detail is superimposed on the vehicle with an unrealistic effect.

The background scenes used to produce the imagery were taken at Fort Hood, Texas, in the Fall of 1977. Slides were shot from a helicopter at altitudes ranging from 50-200 feet. Two 35mm cameras were used so that near and far views of the same area could be obtained. One camera was equipped with a 50mm lens and the other with a zoom lens set to a focal length of 100mm. Therefore, the apparent distance ratio between the far and near views was 2:1.

The background slides were taken on Ektachrome 64 film using a shutter speed of 1/250 - 1/1000 second to avoid blur due to the motion of the aircraft. Some background slides were also taken from a high hilltop. It was found the most useful terrain slides were those taken of areas that had several tree lines separated by open areas. The grass was of a straw color so that the models contrasted quite well in the montage slides. All of the background slides were taken at midday in a northerly direction to assure even illumination by the sun. When a good terrain area was found, 10 to 12 shots were taken from various angles, resulting in a large number of usable picture combinations. Handling two cameras was difficult so that most shots were taken with the 50mm lens while the camera with the longer lens was used to record three or four shots of each area. All terrain slides were shot pointing the camera down at an angle which did not exceed 10 to 20 degrees.

Models

The models used for the target imagery were 1/87 or HO scale plastic models obtained from local hobby shops. Larger, 1/35 scale, models of some armored vehicles were also available, but it was found that a greater variety of vehicles was available in the smaller scale. The 1/87 models usually had adequate detail, but it was necessary to alter several to look more like their prototypes. Since no model of the Soviet T-62 tank was available, one was made from a T-54 model by rearranging the roadwheels and altering the turret and gun. Small searchlights and grab rails were also added to the turret. A searchlight and storage rack were also added to the US M60 tank model, and an M109 SP Howitzer was made from an M108 by adding a larger gun. To eliminate reflections, the models were sprayed with a flat olive drab paint.

The models that were used are listed in Table 3-1. In addition to those models, a model of the French Roland missile system was also used in some of the training imagery. The Roland, when seen from a distance, is similar to several other vehicles. No recognition lesson was prepared for the Roland because of the low number of available photographs of the vehicle.

The vehicle models were photographed on a white background using Plus-X black and white film. The lighting consisted of a single strobe flood unit mounted high and behind the camera. The flood was covered with tissue paper to achieve a diffused lighting. The vehicle models for use in training were photographed at four combinations of azimuth and elevation angle.

Azimuth	Elevation
45°	20°
90°	10°
270°	10°
315°	20°

The negatives were developed and small prints were prepared of each model. The models were printed rather light in tone so that they would not appear too dark in the montage slides.

Montage Slides

Two carousel projectors were placed about 8 feet from a large free standing blackboard. Large sheets of white paper were taped to the blackboard to serve as screens for the projectors. Several types of paper and white cardboard were tried until one was found that closely matched the "whiteness" of the print paper used for the model photos.

It was found that the paper contained in the large tablets commonly used on easels for briefings gave a background on which the edges of the prints were often undetectable.

The training kit required a number of slides showing a group of six different armored vehicles located on a terrain background (Figure 3-2). Transfer letters were used to designate the difference vehicles. A terrain slide was selected that seemed to match the elevation angle of the required tank photos and then the photos were positioned on the projected background so that they "looked right." Each vehicle photo was cut from the print leaving a white border around the image 1/2 to 3/4 inches wide. The cutout images were then attached to the screen with small pieces of double sided tape. After the photos were arranged on the screen, some shadowing was drawn around the base of each vehicle with a felt tip pen to match the shadows shown in the terrain background. If the shadows were not drawn in, the vehicles seemed to "float" away from the terrain. The black and white model photos also tended to pick up some of the background color from the slide so that they no longer appeared as shades of gray.

The resulting composite scene was then photographed with color slide film. Both tungsten film and daylight color film were used to make montage test shots and it was found that the best results were obtained with dayiight Ektachrome film. The 500 watt bulbs of the projectors gave a rather warmish slide with the tungsten film; this was compensated by the bluish tendency of the daylight film which resulted in an overall pleasing tone to the slide.

The scenes were photographed using a 35mm camera with a 70-210mm zoom lens mounted on a tripod just above and behind the projector.

Due to the nature of the light produced by the projector bulb, it was found that normal light meter readings based on the film speed were not accurate. Therefore, a test roll was taken so that the best exposure could be determined. Once the correct exposure value was determined, then the camera's through-the-lens light meter was adjusted to give that exposure under the same set of conditions. Exposures were bracketed by $\pm 1f$ stop as insurance for good exposures. Kodak Ektachrome, type EPR (64) and type EPD (200) were used to photograph the training and simulator imagery. Typical exposures for the EPR film were 1/4 sec. at f3.5 and 1/4 sec. at f5.6 for the EPD film. The latter film seemed to give slightly better results, due probably to the smaller lens opening and its slightly bluer rendition which further counteracted some of the orange in the projector's light. The best montage slides resulted from terrain slides that were on the thin side and of lower contrast. The montage slides that resulted from the process described above appear quite realistic, as may be seen in Figure A-1.

Figure A-1. Sample montage photo.

Handoff Imagery

Photographing the montage slides for the handoff simulator was more difficult than making the montage imagery for the recognition training slide kit. The handoff imagery required that the vehicles shown in the observer's slide be shown in the same locations in the attacker's slide. The two views of the vehicle had to differ by the same angle as did the two terrain shots. The two slides also had to show a meaningful scenario as described in Chapter 3.

Terrain background slide pairs were projected side by side to see what scenarios might apply. When a scenario was decided upon, vehicles were chosen and their placement and relative angular positioning between the two views of a vehicle was determined so that prints could be made. The technique for producing these montage slides was the same as used for the recognition training kit.

In addition to the model negatives used for the recognition training slides, other model negatives were taken of the model set at azimuth angles of 45°, 75°, 285°, and 315° at an elevation angle of 10°. All of these model negatives were printed on proof sheets so that appropriate views could be easily selected. It was found that these four azimuth views gave an adequate selection of angular views to satisfy the requirements of the terrain background slides. The proper target views were chosen by comparing the proof sheet to the projected background slide. Vehicle sizes were chosen subjectively to match the terrain.

The process of making the testing material was rather time-consuming due to the number of steps involved. The resulting slides were sometimes not completely sharp. However, a certain amount of blur added to the realism of the imagery as the actual viewing environment of the pilot would be degraded by vibration and atmospheric conditions. Even so, sharp originals and good quality projection lenses are necessary. The lenses used to photograph the projected image should also be of high quality. Cameras and projectors should also be solidly mounted to avoid vibration problems. Quality could be further improved by using originals photographed in a format larger than 35mm.

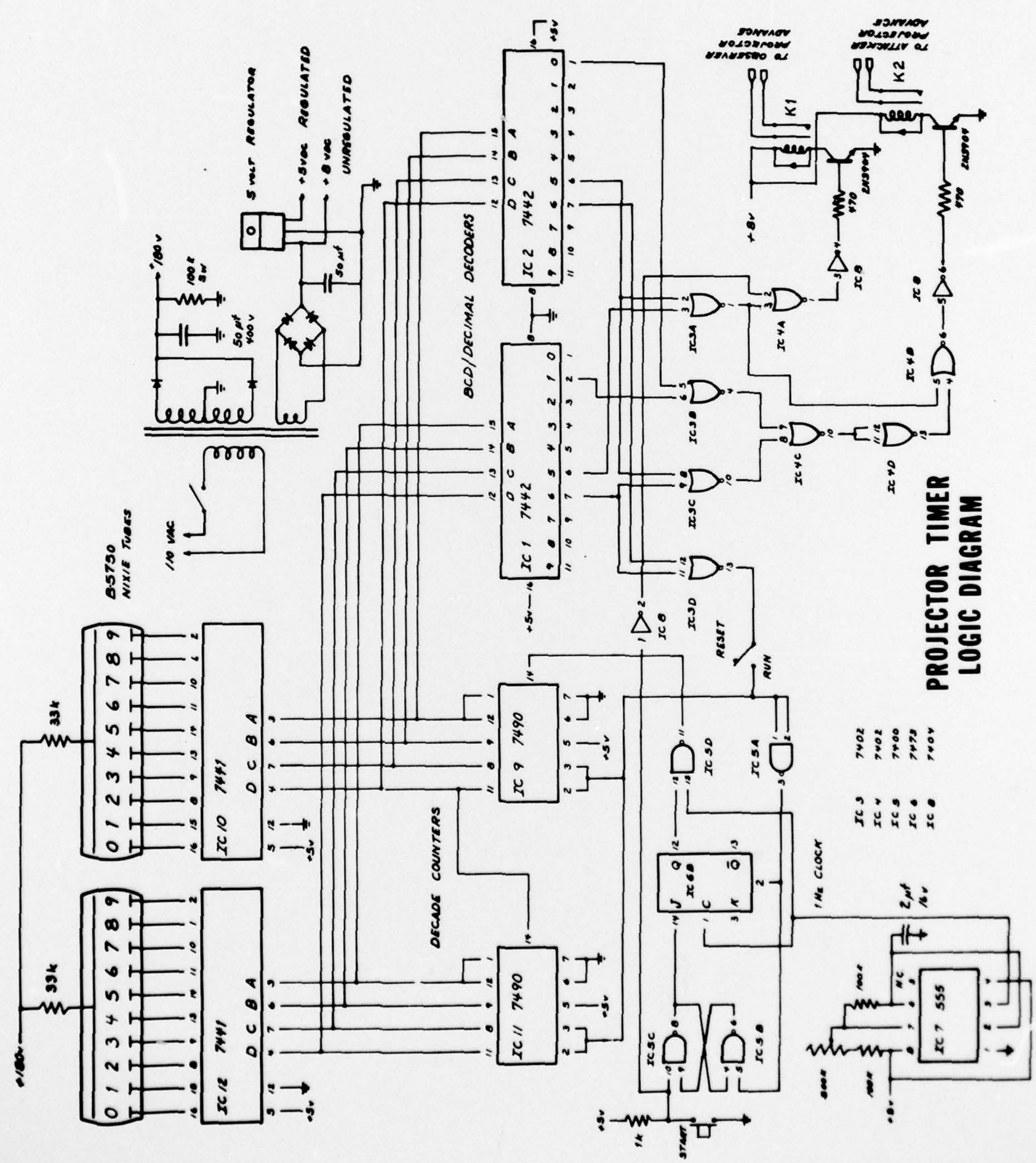
APPENDIX B

PROJECTOR TIMER LOGIC DIAGRAM

Attached is the logic diagram of the projector timer used to cycle the observer and attacker slide projectors. The timer was built using TTL type digital integrated circuits. The operation of the timer is as follows.

IC7 is used as the clock oscillator to provide 1Hz pulses to the two decade counter, IC9 and IC11. Before the START pushbutton is pressed the counter readout tubes display 00. When the START button is pressed it sets the latch formed by IC5B and IC5C. This allows the flip flop, IC6B, to change states on the first clock pulse following the closure of the START pushbutton. Gate IC5D is then enabled to allow clock pulses to reach the units counter, IC9. IC11 is the tens counter. The BCD (Binary Coded Decimal) code for the count is decoded by IC12 and IC10 and displayed on the readout tubes. The BCD count is also decoded by IC1 and IC2 into decimal code for use by the logic gates. The gates of IC3 and IC4 provide the proper drive pulses to relays K1 and K2. *Relay K1 is triggered on Start and* 55 *seconds* and relay K2 is triggered at 10, 55, and 65 seconds. At 66 seconds the counters, the flip flop, and the latch are reset for the next cycle.

The Carousel remote control units were modified by adding wires to the slide advance contacts. These wires were then connected to the timer relay contacts.


DECADE COUNTERS
BCD/DECIMAL DECODERS
5 VOLT REGULATOR
REGULATED
UNREGULATED
110 VAC
RESET
RUN
START
1 Hz CLOCK
TO OBSERVER PROJECTOR ADVANCE
TO ATTACKER PROJECTOR ADVANCE
K1
K2
PROJECTOR TIMER
LOGIC DIAGRAM

APPENDIX C

PERSONAL HISTORY

Position P ____ O ____ Date __________

Paired With ______________________ Pair No. ______

DO NOT MARK ABOVE THIS LINE

Name: ______________________________ Rank: __________
(Last) (First) (MI)

Primary MOS: ________________ Years Service: ________

Age: ________ Present Job Title: ________ Time in Present Job ____

Present Military Unit: ____________________ SSAN __________

How far did you go in school:

a. High school or GED ____

b. Had some college work ____

c. Graduated from college ____

d. Completed some graduate training ____

e. Completed Masters ____

f. Completed PhD ____

g. Post Doctoral ____

Please estimate how many target handoffs you have initiated/received:

a. None ____

b. 1-10 ____

c. 11-50 ____

d. 51-100 ____

e. More than 100 ____

APPENDIX D

INSTRUCTIONS TO SUBJECTS

Observer Instructions

1. General: The purpose of this effort is to study target handoff under simulated static conditions. You will play the role of a Scout Pilot attempting to handoff a military target to an AH.

2. You will both be viewing the target area on your consoles; however, your perspectives will differ. This difference in perspective may be due to differences in range, heading, or altitude. You will not know how much your perspectives differ. The differences will be realistic; however, you will never be on opposite sides of a target. Generally, there will be a difference of 10-15 degrees in your respective headings. There are instances, though, when the target will be partially or completely obscured from the Attacker's view.

3. The attached booklet contains a series of grids with coordinates matching the grid over your screen. There are 12 (22) targets in all and the location of each is shown in the booklet.

4. With each target, the booklet will give a suggestion for a scenario which you should use to initiate the handoff.

These brief scenarios are of two general types: The most common will involve calling in a strike on an armored vehicle. (NOTE: The target may be either Warsaw Pact or NATO. The assumption is that captured friendly vehicles may be operated by opposing forces.) The second sort will involve asking your partner to confirm a possible unfriendly contact.

5. The sequence of events will be regulated by an electronic timer. You will be given a few seconds to look at the appropriate page in your booklet, then the following sequence of events will begin:

Time (sec)	Events: Scout	Events: AH
00	Target area slide on	None
10	Target area slide on	Target area slide on
55	Target area slide off	Closeup slide on
65	None	Closeup slide off

Thus, an image of target(s) emplaced in terrain will appear to you for 10 seconds. You must use this time to locate the target and begin describing its appearance and location. DO NOT USE the grid coordinates, they will not help. After 10 seconds the AH player will receive his view. Continue with your description; you may ask as many questions, and proceed in any manner, as you feel comfortable with. You will have 55 seconds to complete each handoff. The AH player will have two tasks: (1) he must specify the target location on his image, and (2) he will receive a second closeup slide and he must attempt to correctly identify the target. There will be two practice trials followed by 10 (25) target handoffs. If you have any questions, ask them now.

Attacker Instructions

1. General: The purpose of this effort is to study target handoff under simulated static conditions. You will play the role of an Attacker receiving a handoff of a military target from a Scout.

2. You will both be viewing the target area on your consoles; however, your perspectives will differ. This difference in perspective may be due to differences in range, heading, or altitude. You will not know how much your perspectives differ. The differences will be realistic; however, you will never be on opposite sides of a target. Generally, there will be a difference of 10-15 degrees in your respective headings. There are instances, though, when a target which is visible to the Scout will be partially or completely obscured in your view.

3. The attached booklet contains a series of grids matching the grid over your screen. One grid for each handoff problem. There are 12 (27) problems in all. When you are sure of the location, mark it with an "X" in the appropriate grid of the booklet. (NOTE: Be sure that the grid square you mark in your booklet corresponds with the square containing the target on the screen.

4. The sequence of events will be regulated by an electronic timer. You will be given a few seconds to look at the appropriate page in your booklet, then the following sequence of events will begin:

Time (sec)	Events: Scout	Events: AH
00	Target area slide on	None
10	Target area slide on	Target area slide on
55	Target area slide off	Closeup slide on
65	None	Closeup slide off

Thus, an image of target(s) emplaced in terrain will appear to the Scout for 10 seconds. He will use this time to locate the target and begin describing its appearance and location. DO NOT USE the grid coordinates, they will not help. After 10 seconds you will receive your view. You will have two tasks: (1) you must specify the target location on your image, and (2) you will receive a second closeup slide and must attempt to correctly identify the target. As long as the slide is on, continue with the problem. You may ask as many questions, and proceed in any manner, as you feel comfortable with. You will have 45 seconds to locate the target, and an additional 10 seconds to identify the vehicle. Write in your identification in the space provided in the booklet. There will be two practice trials followed by 10 (25) target handoffs. If you have any questions, ask them now.

APPENDIX E

ITEM STATISTICS FOR PROBLEMS 1-15

Table E-1. Correlations Between the Identification Problems
(n = 23)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000	.530*	.411	.460	.368	.589*	.530*	.337	.481	.368	.399	.143	.368	.051	.311
2		1.000	.502	.438	.444	.691**	.589*	.304	.633**	.694**	.509*	.384	.694**	.384	.586*
3			1.000	.659**	.479	.652**	.691**	.438	.394	.479	.397	.066	.479	.066	.405
4				1.000	.572*	.659**	.631**	.368	.411	.572*	.350	.051	.337	.143	.483
5					1.000	.479	.693**	.210	.439	.697**	.147	.054	.395	.195	.163
6						1.000	.691**	.439	.742**	.479	.397	.123	.479	.123	.404
7							1.000	.304	.444	.444	.310	.027	.444	.179	.305
8								1.000	.250	.211	.094	.054	.211	.195	.178
9									1.000	.439	.334	.255	.439	.066	.371
10										1.000	.388	.195	.698**	.195	.503
11											1.000	.112	.628*	.112	.530*
12												1.000	.195	.179	.586*
13													1.000	.444	.503
14														1.000	.309
15															1.000

*$p < .05$
**$p < .01$

Table E-2. Correlations Between the Location Problems
(n = 23)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.000	.242	.094	.098	.054	.142	.000	.020	.102	.304	.092	.171	.011	.092	.094
2		1.000	.385	.405	.110	.163	.000	.123	.226	.120	.314	.388	.073	.242	.500
3			1.000	.156	.086	.225	.000	.032	.212	.112	.094	.088	.190	.147	.150
4				1.000	.322	.066	.000	.204	.171	.141	.465	.243	.127	.098	.291
5					1.000	.204	.000	.255	.143	.384	.195	.008	.037	.305	.086
6						1.000	.000	.296	.247	.131	.142	.271	.183	.142	.225
7							1.000	.000	.000	.000	.000	.000	.000	.000	.000
8								1.000	.233	.066	.210	.038	.172	.250	.214
9									1.000	.051	.102	.195	.132	.133	.024
10										1.000	.195	.199	.253	.304	.086
11											1.000	.060	.240	.092	.387
12												1.000	.122	.060	.096
13													1.000	.011	.226
14														1.000	.147
15															1.000

*Problem 7 was not solved by any subjects; hence, correlations could not be computed.

Table E-3. Percent Correct for the Location Problems
(n = 23)

Group	Problem 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	33	75	25	00	25	92	00	50	58	33	17	34	33	24	42
2*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	00	82	46	09	36	91	00	55	18	27	18	55	18	09	27
4*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

*These groups did not receive these problems.

Table E-4. Percent Correct for the Identification Problems
(n = 23)

Group	Problem 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	68	92	92	92	100	92	100	33	75	100	92	67	100	67	100
2*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	09	46	09	27	64	09	37	00	18	64	37	73	64	73	73
4*	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

*These groups did not receive these problems.